KINEMATICAL ANALYSIS ON DIFFERENT PHASES OF TRACK START AMONG NATIONAL FEMALE SWIMMERS

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A

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CHAPTER – I

INTRODUCTION

"Swimming is simply a moving meditation"

The popularity of swimming is increasing day by day amongst youth due to the parameters determining the attractiveness and inherent physical abilities in it, the difference in position from swimming pool to podium is being determined by small margins. As a result, swimmers, coaches and researchers are looking for a slight edge in each component of swimming. A swimmer's intensity, speed, starts, strokes, turns and finish are the result of many years of tireless work and time. Past literature and researchers have suggested, through various means, that swimming consists of several percent of a good starts, proper technique, physical ability and sharp turns, and accurate finish it is also clarified that till date the status of international swimmers, who have qualified or positioned in the Olympic Games are being vary from each other with a very tiny margin. As important as starts seem to be to swimming races, it is surprising that much of the attention to swim races often focuses on the physiological costs and mechanics of stroke techniques, yet relatively little literature exists regarding the starts.[1]

The importance of being able to swim was very generally recognized in ancient times, notably by the Romans. Roman youth, as early as the Republican era, when trained to bear arms, were made to include in their exercises bathing and swimming in the Tiber, where competitions were frequent. Swimming is for all kind of mankind and any other living creature

[1] Puel, F., Morlier, J., Avalos, M., Mesnard, M., Cid, M., and Hellard, P., **"3D Kinematic and Dynamic Analysis of the Front Crawl Tumble Turn in Elite Male Swimmers."** Journal of Biomechanics, 2012, *45*, p.p. 16-19 & 510–515.

on the planet. It is for a new born child or a weak lady or a healthy person, all may do swimming even can learn also.

Swimmers achieve their fastest speeds off the start, and maximizing performance in this area presents an opportunity to gain a substantial advantage over competitors. Looking more closely at the turns, pushing off the wall generates the next highest race velocities. Additionally, when the overwater phase is considered, we find that the starts make up as much as 10 percent of the distance covered in a race. Research has tended to focus on discrete area of start performance, and tremendous emphasis has been placed on understanding the underwater and out of water phases. Additionally, new technologies such as computational fluid dynamics have increased our knowledge of efficiency in these skills and revealed how best to prepare elite swimmers for the competition.[2]

The track start gets its name from the fact that it mimics the start used in a track sprint; the legs are staggered, and the start is performed by generating an initial drive with the rear leg followed by a front-leg drive. The track start has two main variations: the traditional front-weighted track start, in which most of the swimmer's weight is over the front leg, and the rear-weighted track start, in which the swimmer leans back slightly so that their weight is directed more over the back leg. In both cases, one foot is placed near the rear of the block and the other is positioned with the toes curled around the front edge. Because the front leg provides more of the total propulsive force, it is logical that this should be the swimmer's dominant leg.[3]

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[2] Scott Riewald, Scott Rodeo, **"Science of Swimming Faster",** (Human Kinetics, Champaign, USA), 2015 p.p. 97-99.

[3] Shiqi Thng, Simon Pearson, Evelyne Rathbone and Justin W.L. Keogh, "**The Prediction of Swim Start Performance Based on Squat Jump Force-Time Characteristics",** Peer J, (2020), p.p. 1-18.

The body position on the block must be maximized to achieve the most efficient push on the block and get the body in position to take perfect start to enter in the water. Biomechanics also helps to understand the best body position to reduce drag following the drive, to maximize the speed that is achieved off the starting blocks. Regardless of the type of start used, the favourable angle of the back wedge increases the potential force from the feet using the track start. The coaches and renowned swimmers recommend track start to the swimmers who have a good equilibrium on the block or mastery over the positioning on the block. Track start in swimming strokes, the technique has developed over the years due to close examination and research by sports biomechanics professionals.[4]

The aim of this research work is to analyse various kinematic parameters, investigating out of the water. This research work endeavoured to gain a better understanding of the Track start in swimming and provide information to aid in the selection of a preferred technique during competition or recreational swimming.

Statement of the Problem

After reviewing the related literatures, research studies, various concepts of biomechanics and different start skills of swimming by the research scholar, following problem has been drafted for further research work.

The purpose of this study is to analyse various kinematic variables on different phases of track start among national female swimmers.

[4] Retrieved from https://www.topendsports.com/sport/swimming/science-biomechanics.htm on May 15, 2022.

Objectives of the Study

Research scholar conceptualized a detail investigation in terms of kinematical analysis on different phases of track start among national male and female swimmers, following specific objectives are form for the study:

1) To develop the ideal model of different phases in track start for upcoming aquatic talents.
2) To establish the standards of track start for training and coaching purposes.
3) To increase the objectivity of the track start for further evaluation and assessment procedure.
4) To establish the theory for upcoming swimmers and research scholars to work under similar contexts in future.
5) To determine an approach for the swimmers and coaches to differentiate from traditional approaches to swimming instructions.

Delimitations

Since, the study is conceptualised with a very specify purpose for selected subjects. The research scholar confined this study within the following delimitations;

1. The study will be delimited to national level female swimmers.
2. The study will be further delimited to 20 national level swimmers.
3. The study will be further delimited to the subjects belonging to the age group 15 to 25 years.
4. The study will be further delimited to the following phases of track start in swimming.
    - Phase - I: Block Position
    - Phase - II: Take Off
    - Phase - III: Flight

- Phase - IV: Pre-Aqua Entry

5. The study will be further delimited to the following selected kinematic variables.

- **Linear Kinematic Variables**

Phase	Variables
Block Position	- Centre of Gravity - Width of Stance
Take-off	- Horizontal displacement - Vertical displacement - Centre of Gravity
Flight	- Centre of Gravity - Horizontal Displacement - Vertical Displacement - Velocity during flight
Pre-Aqua Entry	- Centre of Gravity - Vertical displacement - Horizontal displacement - Velocity during pre-aqua entry

- **Angular Kinematic Variables**

  - Angle of Ankle

  - Angle of Knee

  - Angle of Hip

  - Angle of Trunk

  - Angle of Shoulder

  - Angle of Elbow

  - Angle of Wrist

- Angle of Neck

- Angle during Flight

- Angle of Entry

Limitations

1. The data will be collected in natural competitive situations and the action and performance may affect the study. It will be assumed that each subject will give his/her efforts on each trial.
2. Other limitations may be diet, life style, and routine work of the subjects which may vary from one to another.

Hypothesis

On the basis of research cited, books depiction, scientific facts available and research scholar own understandings of this research study following hypothesis will be assumed;

1. All the selected linear kinematical variables may be significant with the selected phases of track start in swimming.
2. All the selected angular kinematical variables may be significant with the selected phases of track start in swimming.

Definition and Explanation of Term

Kinematics

"Kinematics is that branch of the biomechanics that is concerned with the describing the motion of the bodies. It deals with such things that how far a body moves, how fast it moves and how consistently it move."[5]

[5] James G. Hay and Reid, J. Gavin, **"The Anatomical and Mechanical Bases of Human Motion"**, Englewood Cliffs, N.J.: Prentice Hall Inc., 1985,

"Linear kinematics involves the shape, form, pattern, and sequencing of linear movement through time, without particular reference to the forces that cause or result from the motion."

"Angular Kinematics is an angle at a joint formed between the longitudinal axes of adjacent body segments."

Track Start

"The track start is a technique of start in swimming used in a track sprint where the legs are staggered, and the start is performed by generating an initial drive with the rear leg followed by a front-leg drive."[6]

Centre of Gravity

"Centre of gravity is the point around which the body's weight is equally balanced, no matter how the body is positioned."[7]

Reaction Time

"The ability of an individual to respond quickly to auditory, visual and kinaesthetic cues."[8]

Line of Gravity

"An imaginary line that extends vertically through the center of gravity, through the base of support when the body is in balance and outside of the base of support when the body is out of balance."[9]

Displacement

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[6] Scoot Riewald and Scott Rodeo, **"Science of Swimming Faster"**, Human Kinetics, United States Champaign IL, 2015, p.p. 100.
[7] Susan J. Hall, **"Basic Biomechanics"**, Mc Graw Hill Companies, Inc., 1221 Avenue of the Americas, New York, 2012, p.p. 64.
[8] Brian Mackenzie, **"101 Performance Evaluation Tests"**, Electric World Pic, Goswell Road London, UK, 2005, p.p. 55.
[9] Retrieved from **www.larapedia.com/glossary_of_learning_terms/line_of_gravity**, on May 15, 2022.

"Displacement is measured in a straight line from position 1 to position 2, or from initial position to final position."[10]

Velocity

"Velocity is vector equivalents of the scalar quantities distance and speed."[11]

Significance of the Study

In this excellency period of sports, precision and purification of skill has got a lot of importance and research in field has allowed in accelerating the performances. The outcomes of this study may be useful to next generations or sports & physical education professionals in following ways.

1. The outcome of the study may helpful as a track start model in swimming for teaching and coaching purposes.
2. The results of the study may also helpful for corrective measures and error identification in track start performance in swimming.
3. The results of the study may also helpful to the understanding of kinematical approaches of track start in swimming.
4. The study may also be loomed for developing swimming program by professionals, institutions, administrators.
5. The results of the study may also helpful to the future research scholars and supervisors to identify their research problem in related extents in the swimming.

[10] Ibid - 7, p.p. 321.
[11] Ibid - 10, p.p. 323.

CHAPTER - II

REVIEW OF RELATED LITERATURE

The research scholar went through various research work done, source materials and websites for literature related to the problem. The research scholar has given deep thinking to those studies and has gained valuable literature from their findings which are of great help in providing scientific input to the research work. A brief on different review of related literature is present in this chapter.

Kumar Amit (2019)[12], Conducted a research work on biomechanically analysis the square stance and open stance in tennis backhand drive. Thirty male tennis players were purposely selected from the tennis academies of the Gwalior who have played in junior national and right-handed only. Research scholar conceded an in-depth study that selected various major angles of open and square stance, such as right & left shoulder joint, right & left elbow joint, right & left hip joint, right & left knee joint. For further analysis linear kinematic variables Centre of gravity at back swing of the racket, Centre of gravity at the contact, speed of the ball after the contact and horizontal speed of the racket of open and square stance were examined. The performance was recorded on the basis of execution of the skill; was evaluated of the by Hewitt Double Handed Backhand Drive Test. Go Pro Hero 5 camera was used with the frequency of 120 frames per second for obtaining the linear and angular kinematic data. Collected data of the subjects were statistically analysed by employing Paired sample t-test for the comparison of open and square stance backhand drive and Pearson's product moment correlation to

[12] Amit Kumar, **"Biomechanical Analysis of Square Stance and Open Stance in Tennis Backhand Drive"**, Dissertation Abstract, (LNIPE Gwalior, 2019) p.p. 116-120.

examine the relationship of selected linear and angular kinematic variables of square and open stance backhand drive with the speed of the ball after the contact. The level of significance was set at 0.05 for testing the hypothesis. On the basis of the result of the study it was concluded that in the case of square stance and open stance both the stance was different at all the linear and angular kinematic variables except angles at left & right elbow joint, angles at left & right knee joint, Centre of gravity at follow through. In square stance the speed of the ball depends on angles at shoulder joint, angle at left elbow joint, angle at right knee joint Centre of gravity at backswing phase, moment of contact phase, follow through phase and horizontal speed of the racket. In open stance the speed of the ball depends on angles at shoulder joint, angle at left elbow joint, angles at hip joint, Centre of gravity at backswing phase, moment of contact phase, and horizontal speed of the racket. This study was taken by the research scholar as a critical review for her opted research problem.

Wendi Weimar et al. (2019)[13], Submitted a research project with the aims to examine the influences of different push-off techniques on kinetic and kinematic parameters both in and out of the water. Two techniques; (1) a push off that was characterized by rapid extension of knees and hips towards the wall, prior to contact (i.e., no countermovement), and (2) where the swimmer glides into the wall, letting the wall flex the knees in an approximate countermovement or eccentric phase. Twenty trained male and female freestyle swimmers (age 26.1 ± 9.9 years, height 1.61 ± 0.04 m, and weight 65.6 ± 19.3 kg) participated. Data were analysed by employing two (i.e., land and water) 3 (variables of interest) x 2 (push-off type) repeated measures ANOVAs with the alpha

[13] Wendi Weimar, Andrea Sumner, Braden Romer and Jay Patel, **"Kinetic Analysis of Swimming Flip-Turn Push-Off Techniques"**, Research Project, MDPI Journal, School of Kinesiology, Auburn University, Auburn, AL, USA, Vol. 7, Issue 2, (2019), p.p. 32-41.

level set a priori at 05. Results indicated that there were significant main effects for peak perpendicular force ($p < 0.001$), perpendicular impulse ($p = 0.018$), and velocity at 2.5 m ($p = 0.005$) on land. However, no significant effects were found between techniques in the water trials. As many of the participants were master swimmers, it is possible that they were unable to approach the wall in the water at the requisite speed to elicit a benefit from the countermovement.

Serenza S. Felipe et al. (2018)[14], Conducted a research study to compare the kinematics and electromyography of the periscapular muscles in swimmers before and after a 3-min maximal effort test. 16 (Sixteen) competitive swimmers have been selected for the study. Infrared cameras were used to record kinematics in the scapular plane in synchronization with the electromyography system. There was an increase in internal rotation in all angles ($p < 0.05$), an increase of the anterior tilt, with 120° of elevation ($p = 0.04$). The serratus anterior showed a decrease in the intervals of 120-90° and 60-30° ($p = 0.04$; $p = 0.02$). There was a linear relationship between the variation before and after the maximal effort of the anterior tilt in relation to the variation of muscular activation of the transverse trapezius ($p = 0.01$) and the lower trapezius (42%, $p = 0.01$); an internal rotation in 120° and 90° of elevation in relation to the transverse trapezius ($p = 0.01$); and an internal rotation in 60° and 30° of elevation in relation to the serratus anterior ($p = 0.04$, $p = 0.03$). A maximal 3-min effort test resulted in altered scapular biomechanics. More studies are needed to verify if the changes correspond to a risk factor for injuries.

[14] Felipe S.Serenza, Anamaria S.Oliveira, Bruno L.S.Bedo, Fàbio P.Mariano, RodrigoAquino and Paulo R.P.Santiago, **"Biomechanical Analysis of the Shoulder of Swimmers After a Maximal Effort Test",** Journal of Physical Therapy in Sports, Vol. 30, 2018, p.p. 14-21.

Formicola Donato and Rainoldi Alberto (2015)[15], Conducted a study on efficacy of the start techniques' biomechanics in swimming using a kinematic reference data-set. Ten regional swimmers were taken as subjects by using a marker-based stereoscopic approach. Three start techniques, grab start, rear track start, and front track start. The evaluating method was based on; (1) The horizontal component of the dive speed; (2) The angle between the line joining the centre of mass of the swimmer with the intersection point of the pool-water plane and the pool edge plane; (3) The distance between the block and the centre of mass of the swimmer. Differences ($p < 0.05$) in the block position during the start were found between the national swimmers and the references in grab start, front track start, and in rear track start. Before the dive, national swimmers jump up from the block in opposition to the high-level swimmers that drop from the block such as the literature revealed. This study allows: (1) To formulate a model of comparative analysis of data from the literature; (2) To obtain a three-dimensional model of the swimmers using a handy low-cost stereoscopic system; (3) To compare different multi-dimensional biomechanical models designed to describe the diving task. This approach would provide an innovative tool to evaluate the efficacy of the start technique and to assist coaches and trainers to improve their training programs.

Carradori Sergio et al. (2015)[16], Presented his research work in 33rd International Conference of Biomechanics in Sports under International Society of Biomechanics in Sports in swimming

[15] Donato Formicola & Alberto Rainoldi "A Kinematic Analysis to Evaluate the Start Techniques Efficacy in Swimming" Journal of Sports Sciences for Health, Vol 11, (2015), p.p. 57-66.

[16] Sergio Carradori, David Burkhardt, Suzanne Sinistaj, William R. Taylor and Silvio Lorenzetti, **Kinetic and Kinematic Analysis of the Leg Positioning in the Freestyle Track Start in Swimming,** International Society of Biomechanics in Sports (ISBS), 33 International Conference of Biomechanics in Sports (2015)

competitions, the track start is an important part of the race. The aim of this study was to assess and compare the relative positioning of the dominant leg in the preferential freestyle track start. The data was collected using the (Kistler) Performance Analysis System for Swimming (PAS-S) that includes a force measurement and motion analysis system. The results taken from 15 high level competitive swimmers showed that 67.7 % of the subjects naturally position their dominant leg in front. Starting with the dominant leg in front (6.67±0.24) was significantly ($p < 0.001$) faster than in the rear position (7.25±0.23). However, swimmers had faster start when using their preferential track start. Detailed analysis of the swimming start and the footedness allows coaches and athletes to train the fastest starting technique.

Franklin Sathesh R. (2014) [17], conducted a research study on influence of selected biomechanical variables on ball velocity of drag flick in penalty corner and to predict the most influencing variables of ball velocity in penalty corner drag flick in field hockey. Fifty male right-handed drag flickers were selected from Tamil Nadu and Karnataka States as the subjects for this study. The subjects were experienced in penalty corner drag flick techniques. They represented the different departments and universities of Tamil Nadu and Karnataka States namely, Indian Overseas Bank, Indian Bank, Integral Coach Factory, Customs and Central Excise, University of Madras, SRM University and Bangalore University. The age of the subjects ranged from 18 to 30 years. The measurements were recorded by using the standard equipment, which was available at hand. The body weight of each subject was recorded in kilogram (kg) by using weighing machine. Height of each subject was recorded in meter by

[17] R. Sathesh Franklin**, "Biomechanical Analysis of Penalty Corner Drag Flick in Field Hockey",** Dissertation Abstract, (TNPESU Chennai, 2014) p.p. 161-165.

using stadiometer and age of each subject was measured in Chronological order. Four key phases (Approach Phase, Contact Phase, Drag Phase and Follow Through Phase) were analysed for the study. The Pylon Basler Gige and Canon EOS 5D Mark II cameras were used to capture the performance (ball velocity) of players in penalty corner drag flick in field hockey. and the selected biomechanical variables were measured with KINOVEA software. The collected data were analysed with Pearson product moment correlation, partial correlation and multiple regression. The Pylon Basler Gige and Canon EOS 5D Mark II cameras were used to capture the performance (ball velocity) of players in penalty corner drag flick in field hockey. The ball velocity was negatively correlated with time of approach (10%) and total distance of approach (12.3%). The ball velocity had a positive correlation with distance of right foot from the ball (35.8%). The time of approach was positively correlated with total distance of approach (16%) and distance of right foot from the ball (10.5%). The total distance of approach was positively correlated with distance of right foot from ball (25.9 %). The ball velocity is negatively correlated with distance of ball from right foot (2%) and time of left foot contact with ground (34.1%). 164 The distance of ball from right foot was negatively correlated with time stick contact with ball (2.1%). The ball velocity was positively correlated with time of stick contact with the ball (16.6%). The ball velocity was negatively correlated with drag time (5.1%), stance width (44.8%) and stick angle (7.2%). The drag length was negatively correlated with stance width (24.1%) and stick angle (0.2%). The drag time was negatively correlated with drag velocity (28.9%) and stick angle (53.6%). The drag velocity was negatively correlated with left knee angle (24.6%) and stance width (0.4%). The left knee angle was negatively correlated with stance width (30.6%) and stick angle (23.7%). The stance width was negatively correlated with stick angle (30.8%). The ball velocity was negatively

correlated with total time of drag flick (10.5%). The stick velocity was negatively correlated with time of ball release after left foot contact with ground (5.7%) and total time of drag flick (25%). The distance of left foot from the ball was negatively correlated with total time of drag flick (28%) with 0.05 level of significance.

Vantorre J. et al. (2010)[18], studied to analyse the differences between preferential and non-preferential start technique, and the inter-trial variability. Seven elite swimmers, who used track start as preferential technique, realised three trials in track and grab start. The kinematical analysis assessed the durations of the block, flight, entry, glide, leg kicking and full swimming phases to the 15 m. mark. Aerial (sum of block and flight phase with head mark) and underwater (from entry to the head reach the water surface) phases, number of underwater leg undulations and arm stroke to 15m were also measured. The kinetic analysis assessed reaction and impulse time and total impulses in vertical and horizontal axis. Track start, as preferential technique, had shorter block and entry phases but similar flight phase. In grab start, swimmers spend more time in the impulse and obtained higher vertical impulse values; moreover, higher inter-trial variability was found for non-preferential technique suggesting lower efficiency. Differences of kinematics and kinetics observed tended to explain that the preferential technique is highly stabilised and reproducible by the swimmers. However, no differences on the 15m start time performance are observed between the two techniques, confirming the high skill level of the swimmers, and notably their capability to compensate lower block efficiency by effective underwater phases. Indeed, the relative

[18] J. Vantorre, L. Seifert, R.J. Fernandes, J.P. Vilas-Boas and D. Chollet **"Biomechanical Influence of Start Technique Preference for Elite Track Starters in Front Crawl",** The Open Sports Sciences Journal, University of Rouen, France, Vol 3, (2010), p.p.137-139.

duration of the underwater phases, the number of leg undulations and arm strokes are very similar in both techniques.

CHAPTER – III

PROCEDURE

In this chapter selection of subjects, selection of variables, criterion measures, procedure for collection of data and the statistical techniques employed for the analysis have been described.

Selection of Subjects

Twenty (20) female swimmers will be selected purposely to conduct this study from the National Swimming Competition. All the subjects will be national players of swimming possess certain level of technique of track start. The age of all subjects will be ranged from 15 to 25 years only. Before conducting of tests, the research scholar will meet with all selected subjects to describe entire testing procedures in detail for clarification of doubts about the test procedures. No motivation and encouragement techniques will be used to get the best for the subjects, each subject perform separately in the entire investigation process with great eagerness and cooperation.

Selection of Variables

For the Kinematical analysis of different phases of track start among national male and female swimmers following kinematic variables will be selected:

Dependent Variables

A. Phase - I: Block position
B. Phase - II: Take Off
C. Phase - III: Flight (Position in Air)
D. Phase - IV: Entry into Water

Independent Variables

- **Linear Kinematic Variables**

Phase	Variables
Block Position	- Centre of Gravity - Width of Stance
Take-off	- Horizontal Displacement -Vertical Displacement - Centre of Gravity
Flight	- Centre of Gravity - Horizontal Displacement - Vertical Displacement - Velocity during flight
Pre-Aqua Entry	- Centre of Gravity -Vertical displacement -Horizontal displacement -Velocity during pre-aqua entry

- **Angular Kinematic Variables**

  - Angle of Ankle
  - Angle of Knee
  - Angle of Hip
  - Angle of Trunk
  - Angle of Shoulder
  - Angle of Elbow
  - Angle of Wrist
  - Angle of Neck
  - Angle during Flight

- Angle of Entry

Reliability of Data

The reliability of data will be assured by establishing the reliability of instruments and tester's competency.

Many sophisticated devices, instruments and applications will be used for the purpose of the study such as GoPro Hero 5 High speed action camera, Bushnell Speed Gun and Kinovea Software. All the instruments will be purchased or procured from renowned firms. And also, the data revealed no fluctuation when taken in different parameters using the same instruments. All measurements related to the selected kinematic variables will be taken by scholar personally under the valuable guidance of expert, therefore, data collection for the present study will be considered to be reliable.

Research scholar is herself an experienced scholar of sports biomechanics and also did her post-graduation research thesis under the same capacity. Researcher is well-versed with the technique of conducting the tests and collecting the data for further analysis. The scholar will also take assistance from the associated swimming colleagues for the testing procedures and whole testing process and data collection will be conducted under the kind guidance of her supervisor.

Criterion Measures

Linear Kinematic Variables

Variables	Measures/ Unit
- Centre of Gravity	- Kinovea Software/ ($^{c.m.}$)
- Width of Stance	- Kinovea Software/ ($^{c.m.}$)
- Horizontal displacement	- Kinovea Software/ ($^{c.m.}$)
-Vertical displacement	- Kinovea Software/ ($^{c.m.}$)

- Centre of Gravity	- Kinovea Software/ ($^{c.m.}$)
- Centre of Gravity	- Kinovea Software/ ($^{c.m.}$)
- Horizontal Displacement	- Kinovea Software/ ($^{c.m.}$)
- Vertical Displacement	- Kinovea Software/ ($^{c.m.}$)
- Velocity during flight	- Bushnell Speed Gun/ ($^{m./s.}$)
- Centre of Gravity	- Kinovea Software/ ($^{c.m.}$)
- Vertical displacement	- Kinovea Software/ ($^{c.m.}$)
- Horizontal displacement	- Kinovea Software/ ($^{c.m.}$)
-Velocity during pre-aqua entry	- Bushnell Speed Gun/ ($^{m./s.}$)

Angular Kinematic Variables

Variables	Measures/ Unit
- Angle of Ankle	- Kinovea Software/ (^{o})
- Angle of Knee	- Kinovea Software/ (^{o})
- Angle of Hip	- Kinovea Software/ (^{o})
- Angle of Trunk	- Kinovea Software/ (^{o})
- Angle of Shoulder	- Kinovea Software/ (^{o})
- Angle of Elbow	- Kinovea Software/ (^{o})
- Angle of Wrist	- Kinovea Software/ (^{o})
- Angle of Neck	- Kinovea Software/ (^{o})
- Angle during Flight	- Kinovea Software/ (^{o})
- Angle of Entry	- Kinovea Software/ (^{o})

Statistical Procedure

1. For Kinematical analysis on different phases of track start among national female swimmer descriptive statistics will be used.
2. All the Data will be analysed with the help of SPSS version 20.
3. For testing hypothesis, the level of significance will be set at 0.05.

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